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BACTERIOLOGICAL PREIMPOUNDMENT STUDY IN THE UPPER LEAF RIVER WATERSHED, SMITH COUNTY, MISSISSIPPI

Environmental Protection Agency
Athens, Georgia

August 1972

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TS-04-73-01

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Region IV
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TABLE OF CONTENTS

Title	Page No.
INTRODUCTION	1
SUMMARY AND CONCLUSIONS	3
Summary	3
Conclusions	5
AUTHORITY	8
STUDY AREA	9
WASTE SOURCES	10
STUDY FINDINGS	11
Impoundment Site 8	12
Bacterial Results	12
Coliform Bacteria	12
Fecal Streptococcus Bacteria	14
Salmonella Isolation	15
Flow Determinations	16
Temperature	17
Impoundment Site 4	18
Bacterial Results	18
Coliform Bacteria	18
Fecal Streptococcus Bacteria	19
Salmonella Isolation	19
Flow Determination	19
Temperature	20
PROJECTED BACTERIOLOGICAL WATER QUALITY OF THE PROPOSED IMPOUNDMENTS	20
REFERENCES	24

APPENDICES

Appendix A, Study Methods
Appendix B, Rainfall Data
Appendix C, Bacterial, Temperature, and Flow Data

LIST OF TABLES

Number	Title	Follows Page No.
I	Station Locations	9
II	Impoundment Site 8 Bacteriological Data Summary - July 1971 Study	12
III	Impoundment Site 8 Bacteriological Data Summary - May 1972 Study	12
IV	Impoundment Site 8 Bacteriological Data Summary - July 1971 - May 1972 Studies	12
V	Comparisons of the Geometric Mean Fecal Coliform and Fecal Streptococci Bacteria Densities for the Entire Study Period	15
VI	*Salmonella* Serotypes Recovered During the July 1971 and May 1972 Studies	16
VII	Average Estimated Streamflow During the July 1971 and May 1972 Studies	16
VIII	Water Temperature Data Summary for the July 1971 and May 1972 STudies	17
IX	Impoundment Site 4 Bacteriological Data Summary - May 1972 Study	18
X	Fecal Coliform Bacteria Densities at Impoundment Site 4 Stations During Period of Surface Runoff	18
XI	Identification Scheme for *Salmonella* Suspects	Appendix A

LIST OF FIGURES

Number	Title	Follows Page No.
1	Map of Impoundment Site 8 Study Area	9
2	Map of Impoundment Site 4 Study Area	9
3	Fecal Coliform Bacteria Densities at Impoundment Site 8 Stations During July, 1971 and May, 1972 Studies	13
4	Comparison of the Average Flows at Shongelo and Big Shongelo Creek	16
5	Comparison of the Fecal Coliform Density and Flow at Station 07 During the May 1972 Study	20
6	Fecal Coliform Die-off Curve During Summer Months	22

INTRODUCTION

The U.S. Department of Agriculture, Soil Conservation Service, plans to construct two multipurpose impoundments in the Upper Leaf River Watershed in Smith County, Mississippi.(1) Primary contact recreation is included in the proposed uses for the impoundments. At the request and support of the Soil Conservation Service (SCS), a bacterial water quality study was conducted to determine the bacterial quality of the stream waters within the watershed, the adequacy of the water quality for contact recreation, and possible control measures to implement if the quality proved unsatisfactory.

Waters subjected to fecal contamination originating from livestock, wildlife and/or humans are characterized by the presence of bacteria which inhabit the intestinal tracts of warm-blooded animals. The coliform group of bacteria is discharged in large numbers in warm-blooded animal excreta. This bacterial group contains several genera with similar biochemical properties.

Results of work by Eijkman(2), Hajna and Perry(3), Clark, et. al. (4), Geldreich, et. al.(5)(6), and Geldreich(7) have enhanced the differentiation of the coliform bacteria group into subgroups of fecal and non-fecal origin. The fecal coliform bacteria group is presently the most reliable bacterial measure of fecal contamination in environmental waters.

Though most are non-pathogenic, coliform bacteria indicate the probable presence of enteric pathogens resulting from contamination by fecal material. Some enteric pathogens, if ingested, may cause

gasteroenteritis, dysentery, typhoid fever, and/or paratyphoid fever. Although not necessarily caused by enteric pathogens, ear, eye, nose, throat and skin infections are commonly contracted from contact with polluted waters. Viral diseases, such as infectious hepatitus, may also result from ingestion of waters subjected to fecal contamination.

The most widely accepted bacterial criterion for environmental waters used for primary contact recreation is based on the fecal coliform group. A recommended level of fecal coliform bacteria not to exceed a log mean of 200/100 ml, based on at least five samples collected during any 30-day period, nor more than 10 percent of the total number of samples exceeding 400/100 ml is regarded as offering the bather reasonable safeguards.

It should be noted that no environmental water should be considered completely safe for primary contact recreation regardless of the bacterial indicator density of the water. There will be some health risks involved for the water user; however, the risks should be reduced in waters with low indicator densities.

All samples collected for microbiological analysis were examined for fecal coliform and fecal streptococci bacteria densities. Examinations for the presence of Salmonella, an enteric pathogen, were made at selected stations.

SUMMARY AND CONCLUSIONS

SUMMARY

1. At the request of the U.S. Department of Agriculture, Soil Conservation Service, preimpoundment bacteriological studies were conducted during July 1971 and May 1972 at the sites of two proposed multipurpose impoundments in the Upper Leaf River Watershed in Smith County, Mississippi.
2. A waste inventory of the drainage areas for the two impoundments disclosed no municipal or industrial waste sources. Waste sources within the drainage areas are limited to agriculturally related activities and wildlife.
3. Some streams within each drainage are used as receptacles for solid waste disposal (e.g. household garbage, animal carcasses, and automobile parts).

Impoundment Site 8

4. The mean fecal coliform bacteria densities at stations within the Site 8 impoundment area ranged from 13/100 ml (Station 05) to 660/100 ml (Station 03).
5. The mean fecal coliform densities were generally higher during the July 1971 than during the May 1972 study.
6. The ratio of mean fecal coliform to mean fecal streptococcus densities within the Site 8 impoundment area ranged from 0.14:1 to 2.60:1.

7. Salmonella were isolated at all sampling stations within the Site 8 impoundment area. Serotypes identified were: S. give, S. luciana, S. muenchen, S. gaminara, S. newport, S. bredeney, S. java, S. infantis, S. bareilly, and S. heidelberg.
8. Estimated streamflows within the Site 8 impoundment area ranged from 0.3 to 1.2 cfs during the July 1971 study and from 0.3 to 4.8 cfs during the May 1972 study.

Impoundment Site 4

9. Sample sites selected within the Site 4 impoundment area were not sampled during the July 1971 study due to lack of flow. Sampling at several stations within this area during May 1972 was possible only after a period of rainfall.
10. The mean fecal coliform densities ranged from 2800 to 8200/100 ml at the sampling stations within the Site 4 impoundment area during May 1972.
11. The ratio of mean fecal coliform to fecal streptococci densities within the Site 4 impoundment area ranged from 1.37:1 to 2.68:1.
12. One station (Station 07) within the Site 4 impoundment area was sampled for the presence of Salmonella. S. inverness was identified from this station.
13. Estimated screamflows ranged from 0 to 7.0 cfs at the sampling sites within the Site 4 impoundment area during the May 1972 study.

CONCLUSIONS

1. After completion of each impoundment, the retention time in each reservoir will result in a decrease in bacterial densities and general improvement of the bacterial water quality.
2. The headwaters of the reservoirs should not be used for primary contact recreation under any circumstance.
3. Commercial and land developments along each impoundment periphery and within each drainage area should be adequately controlled if bacterial water quality is to be maintained.
4. Localized use of chicken litter as agricultural fertilizer may serve as a contributor of bacterial pollution within each impoundment drainage area. Attempts should be made to arrive at agreements with landowners to apply these wastes only during the non-recreational season.
5. The continued use of streams as solid waste receptables will degrade the water quality within each drainage area. Efforts should be made by the appropriate authority to halt this practice of waste disposal.

Impoundment Site 8

6. Projected bacteriological quality in the Site 8 impoundment area will be of sufficient quality to support recreational water contact activities. The bacteriological quality of the impoundment should be well within the recommended limits (a monthly mean fecal coliform level not to exceed 200/100 ml) for primary contact recreation.

7. The bacterial water quality of the streams within the proposed Site 8 impoundment area indicate no major waste sources. The mean fecal coliform bacteria densities were less than 400/100 ml except at one station during both survey periods.

8. The mean fecal coliform bacteria density of 940/100 ml at Station 03 during the July 1971 survey apparently resulted from a localized problem associated with solid waste disposal and wildlife. The results of the May 1972 survey indicated no bacterial problem at this station.

9. A waste source inventory indicated the fecal contamination within the Site 8 impoundment area resulted from non-human sources. Fecal coliform to fecal streptococci ratios further support this conclusion.

10. The isolation of Salmonella serotypes within the Site 8 impoundment area is indicative not only of fecal pollution but establishes a potential for disease transmission.

Impoundment Site 4

11. Projected bacteriological quality in the Site 4 impoundment area will be marginal for the support of recreational water contact activities. Based on existing bacterial densities and hydrologic conditions in the streams tributary to the proposed impoundment, the impoundment will be subjected to periodic rapid influxes of runoff carrying extremely high densities of pollution indicator organisms. Recommended use of this proposed impoundment of water

contact recreation should be delayed until sufficient post-impoundment studies are conducted that demonstrate sufficient water quality to support primary contact activities.

12. Soil characteristics within the Site 4 impoundment drainage area promote a rapid runoff of precipitation. Streamflows within the drainage areas are almost entirely dependent upon surface runoff.

13. Fecal wastes from domestic animals and wildlife within the Site 4 impoundment drainage area results in a pronounced degradation of the bacterial water quality of the streams during periods of surface runoff.

AUTHORITY

The U.S. Environmental Protection Agency study of the Upper Leaf River Watershed preimpoundment areas was performed at the request of the U.S. Department of Agriculture, Soil Conservation Service. Authority for such studies is contained in Section 5(a) of the Federal Water Pollution Control Act as amended (33 USC 466 et. seq.).

STUDY AREA

The two study areas for the proposed multipurpose impoundments are located in the Upper Leaf River Watershed in Smith County, Mississippi. Figures 1 and 2 depict these study areas.

Impoundment Site 4 is located approximately three miles northeast of Pineville, Mississippi, in primarily forested and pasture lands. The site is situated in the Forest Hill geologic formation comprised of sandy and silty clays. The dam site will be located on Ichusa Creek. The drainage area to be regulated by this structure will be approximately 9,364 acres located in Smith and Scott Counties. The surface area of the completed impoundment will be approximately 800 acres.

Impoundment Site 8 is located approximately five miles northeast of Raleigh, Mississippi, in primarily forested and pasture lands. The site falls within the Vicksburg geological group containing a mixture of sandy clays and non-plastic sands. The dam site will be located on Shongelo Creek. The drainage area to be regulated by this structure will be approximately 7,690 acres and the completed impoundment will have a surface area of approximately 345 acres.

Sampling station locations for both study areas are contained in Table I and shown in Figures 1 and 2.

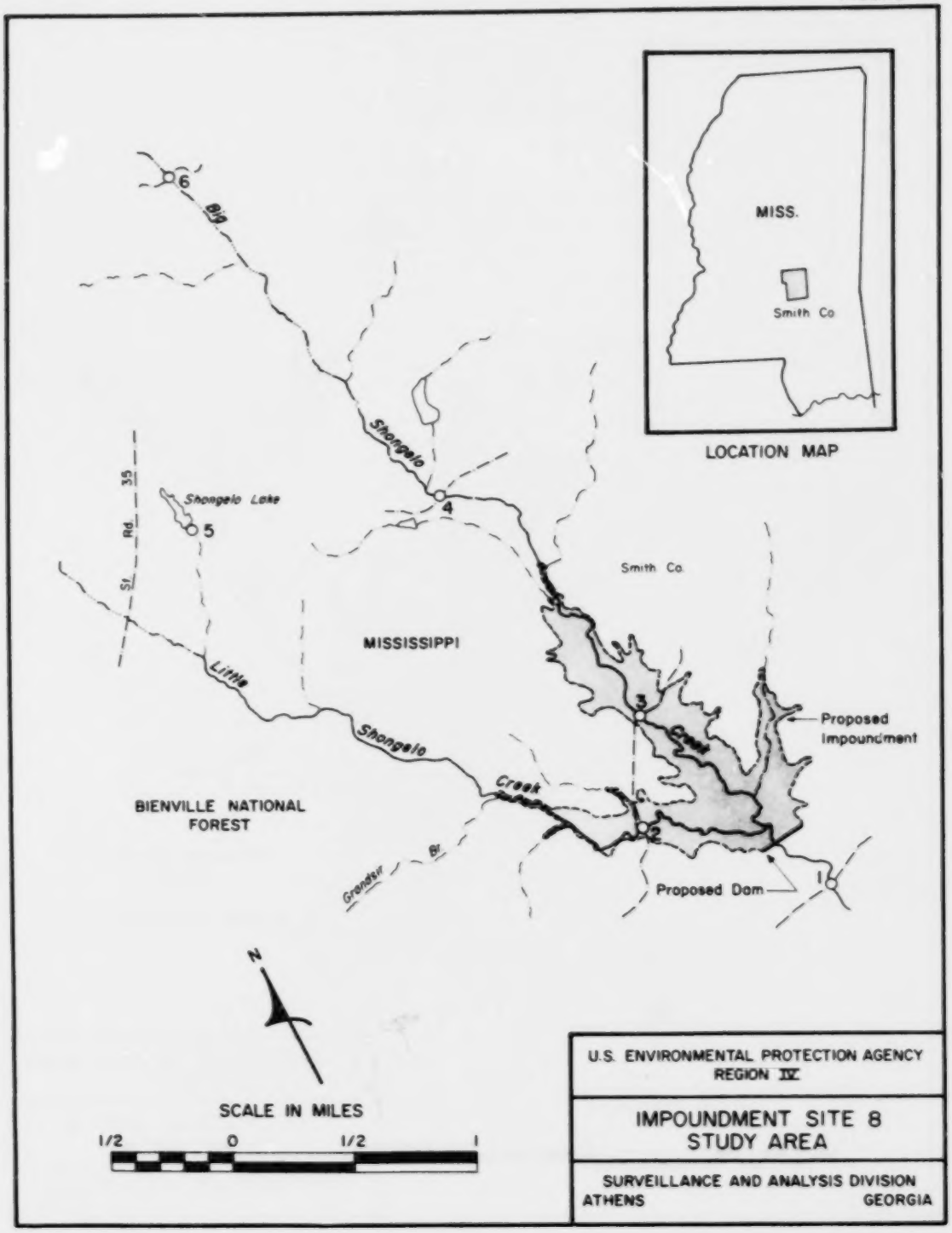
9-a

TABLE I

STATION LOCATIONS

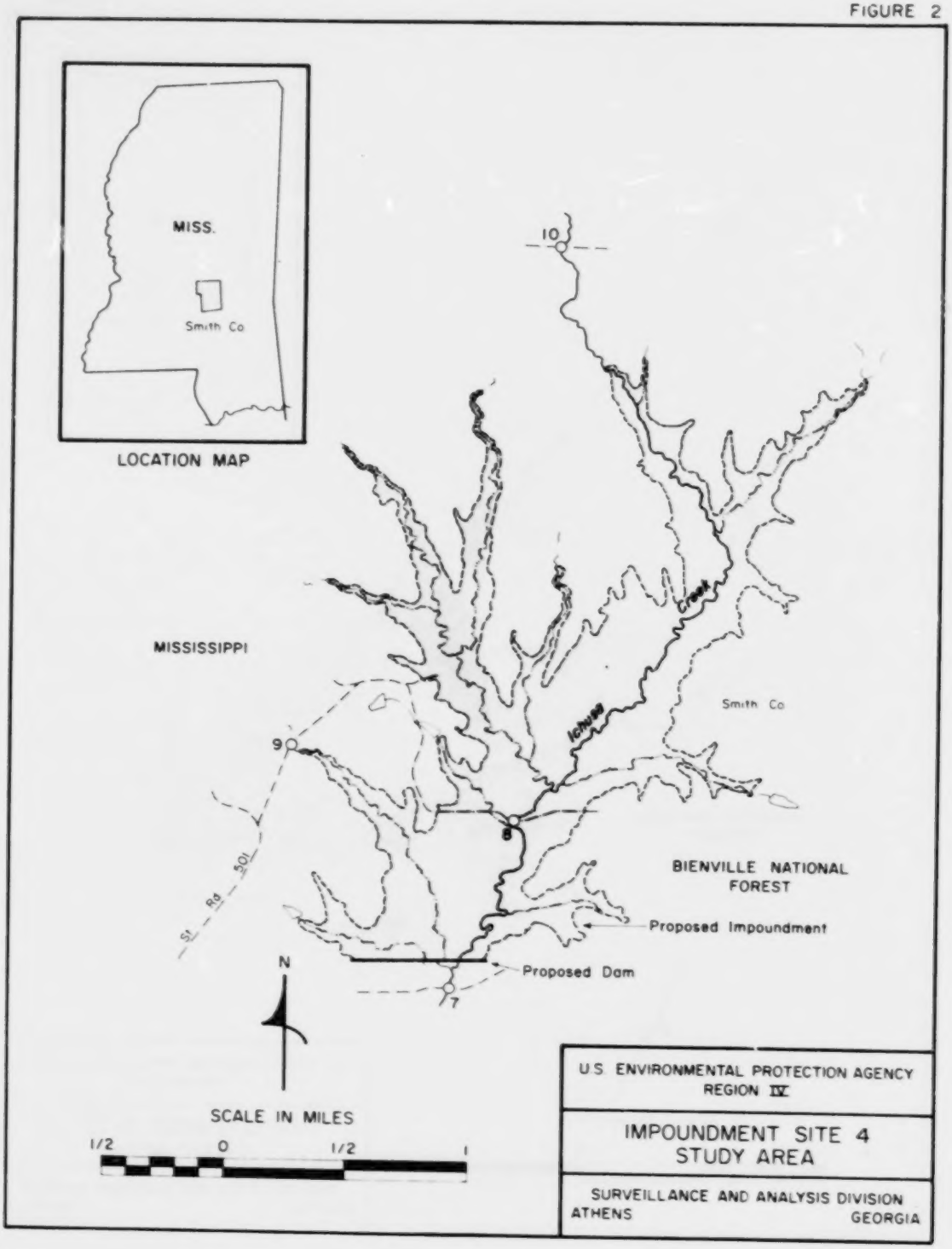
Station	Location
01	Shongelo Creek 0.5 mile downstream from the confluence of Big Shongelo and Little Shongelo Creeks at County Road Bridge (Section 33,T3N,R8E).
02	Little Shongelo Creek 0.6 mile upstream from the confluence with Big Shongelo Creek at County Road Bridge (Section 29, T3N,R8E).
03	Big Shongelo Creek 0.8 mile upstream from the confluence with Little Shongelo Creek (Section 29, T3N,R8E).
04	Big Shongelo Creek 1.5 miles upstream from Station 03 at County Road Bridge 1.2 miles from State Highway 35 (Section 17,20,T3N,R8E).
05	Shongelo Recreational Area Lake at spillway (Section 18, T3N,R8E).
06	Big Shongelo Creek at U.S. Forest Service Road 539A (Section 8,T3N,R8E).
07	Ichusa Creek at County Road Bridge 1.1 miles from State Highway 501 (Section 28,T4N,R9E).
08	Ichusa Creek at County Road Bridge 0.8 mile upstream from Station 07 (Section 28,T4N,R9E).
09	Unnamed creek tributary to Ichusa Creek at County Road culvert 0.6 mile from State Highway 501 (Section 20,T4N,R9E).
10	Unnamed creek tributary to Ichusa Creek at U.S. Forest Service Road 520 Bridge (Section 9,T4N,R9E).

FIGURE 1


MISS.
Smith Co.
LOCATION MAP
6
Big
Shongelo
4
Shongelo Lake
5
St. Rd. 35
Smith Co.
MISSISSIPPI
Little
Shongelo
Creek
3
Proposed Impoundment
Creek
BIENVILLE NATIONAL FOREST
2
Grandsir Br.
Proposed Dam
1
N
SCALE IN MILES
1/2 0 1/2 1
U.S. ENVIRONMENTAL PROTECTION AGENCY
REGION IV
IMPOUNDMENT SITE 8
STUDY AREA
SURVEILLANCE AND ANALYSIS DIVISION
ATHENS GEORGIA

9-C

FIGURE 2


MISS.
Smith Co
LOCATION MAP
10
MISSISSIPPI
Creek
Ichusa
Smith Co
9
8
BIENVILLE NATIONAL FOREST
St. Rd. 501
Proposed Impoundment
Proposed Dam
7
N
SCALE IN MILES
1/2
0
1/2
1
U.S. ENVIRONMENTAL PROTECTION AGENCY
REGION IV
IMPOUNDMENT SITE 4
STUDY AREA
SURVEILLANCE AND ANALYSIS DIVISION
ATHENS
GEORGIA

WASTE SOURCES

A waste source inventory revealed no industrial or municipal wastes are discharged within the drainage areas of the proposed impoundments. The inventory revealed some agriculturally related waste sources within each drainage area.

Within the Site 4 drainage area there are two poultry farms with approximately 30,000 broilers per farm. These are closed operations and the poultry litter is removed about twice a year and routinely spread onto pasture land. In addition, there are 12 farms with approximately 30 head of cattle per farm. There are no swine operations within this drainage area.

The Site 8 drainage area has one poultry farm with approximately 1500 laying hens. Litter from this operation is removed about twice yearly and spread onto pasture land. There are six farms with about 20 head of cattle per farm and there are four general farming operations. There are no swine operations located within this drainage area.

There appeared to be abundant wildlife populations inhabiting both drainage areas.

STUDY FINDINGS

Bacteriological water quality studies were conducted at two proposed impoundment sites in the Upper Leaf River Watershed from July 13 through 19, 1971, and May 1 through 4, 1972.

Bacteriological samples were collected and quantitatively analyzed for fecal coliform and fecal streptococci bacteria as described in Appendix A. Qualitative determinations for members of the genus Salmonella were made at seven selected stations. The isolation and identification methods are described in Appendix A. In addition, water temperatures were recorded and, where possible, stream flows measured.

The initial study was terminated in July and rescheduled because of the lack of any streamflow in the Site 4 drainage area. The Site 8 drainage area streams had flow and were sampled during the July 1971 study.

During the May 1972 study, there was streamflow in the principal stream (Ichusa Creek) in the Site 4 drainage area. In addition, approximately one inch of rainfall in the Site 4 drainage area during this study period resulted in adequate streamflows for a short time (Appendix B). The effect that surface runoff had on the bacterial quality of the streams in this area was determined. All Site 8 stations had adequate flow and were sampled during this study.

IMPOUNDMENT SITE 8

Bacterial Results

Coliform Bacteria

The fecal coliform bacteria data summaries for the July 1971 and May 1972 studies are presented in Tables II and III. In general, the mean fecal coliform bacteria densities were slightly lower at the different stations during May 1972 than during July 1971. This is graphically illustrated in Figure 3. The combined data summary for the two studies are presented in Table IV. All fecal coliform data are contained in Appendix C.

Station 01, located on Shongelo Creek immediately downstream from the proposed dam site, had a mean[1/] fecal coliform bacteria density of 320/100 ml for the entire study (Table IV). This density reflects the combined tributary bacterial input for the drainage area since all tributaries flow into Shongelo Creek above this point.

Little Shongelo Creek as measured at Station 02 contributed a mean fecal coliform bacteria density of 340/100 ml. There was little difference between the July 1971 and May 1972 mean fecal coliform densities at this station (Tables II and III).

Station 03, located on Big Shongelo Creek had a combined mean fecal coliform density of 660/100 ml (Table IV) which was the highest of any station in the Site 8 study area. As seen in Tables II and III

1/ All means referred to in this report are geometric means.

TABLE II

Impoundment Site 8 Bacteriological Data Summary - July 1971 Study

Station	Fecal Coliform Bacteria/100 ml				Fecal Streptococci Bacteria/100 ml				
	Maximum	Minimum	Average	Geo. Mean	Maximum	Minimum	Average	Geo. Mean	No. of Samples
01	2,600	190	640	360	2,900	1,000	1,600	1,500	6
02	510	210	350	330	1,900	760	1,300	1,200	6
03	3,800	510	1,200	940	4,200	2,400	2,900	2,800	6
04	480	240	320	310	2,900	1,900	2,200	2,200	6
05	50	17	27	25	18	1	7	4	6
06	380	110	250	230	3,800	1,400	2,600	2,400	6

TABLE III

Impoundment Site 8 Bacteriological Data Summary - May 1972 Study

Station	Fecal Coliform Bacteria/100 ml				Fecal Streptococci Bacteria/100 ml				No. of Samples
	Maximum	Minimum	Average	Geo. Mean	Maximum	Minimum	Average	Geo. Mean	
01	1,200	95	480	250	1,200	200	700	550	3
02	460	260	370	360	1,200	700	900	880	3
03	610	180	370	330	1,500	600	930	860	3
04	280	130	210	200	1,900	820	1,300	1,200	3
05	10	2	5	3	10	5	7	7	3
06	400	110	220	190	760	350	560	520	3

TABLE IV

Impoundment Site 8 Bacteriological Data Summary - July, 1971-May, 1972 Study

Station	Fecal Coliform Bacteria/100 ml				Fecal Streptococci Bacteria/100 ml				
	Maximum	Minimum	Average	Geo. Mean	Maximum	Minimum	Average	Geo. Mean	No. of Samples
01	2,600	95	580	320	2,900	200	1,300	1,100	9
02	510	210	350	340	1,900	700	1,200	1,100	9
03	3,800	180	950	660	4,200	600	2,200	1,900	9
04	480	130	280	270	2,900	820	1,900	1,800	9
05	50	2	19	13	18	1	7	5	9
06	400	110	240	220	3,800	350	2,100	1,600	9

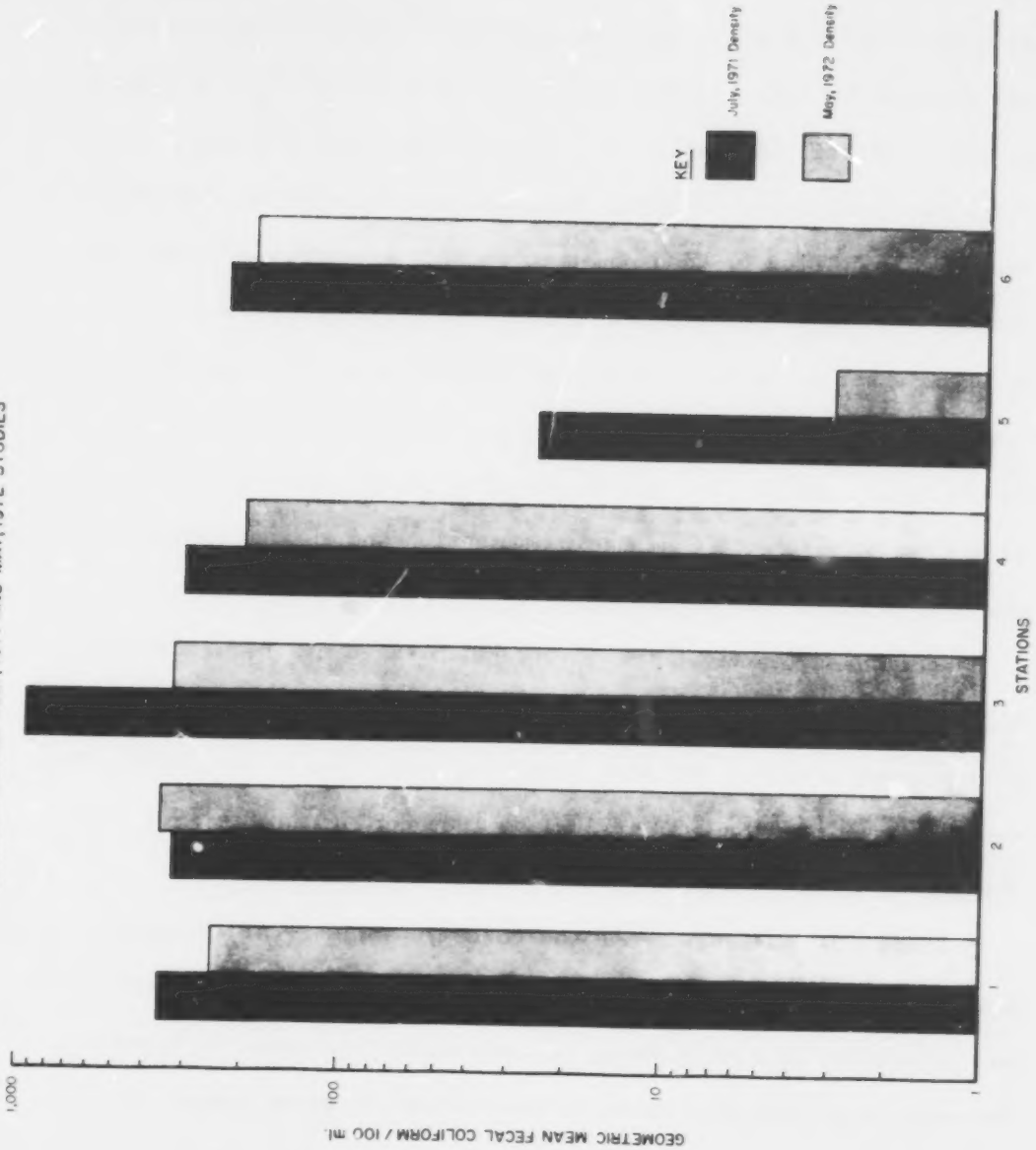
and Figure 3, there was a large difference between the July 1971 and May 1972 mean fecal coliform bacteria densities. There are several factors to note regarding July 1971 mean fecal coliform bacteria density of 940/100 ml. First, an elevated fecal coliform density was measured on July 19 which resulted from surface runoff produced by heavy rainfall (Appendix C). In addition, there was clandestine disposal of solid waste within the immediate vicinity of Station 03. The waste consisted of dead poultry, poultry viscera, feathers, and household garbage. Samples were collected upstream of these wastes; however, numerous animal tracks were evident along both banks of the creek and there were indications that animals were scavenging the wastes. In contrast, during the May 1972 study, there was no evidence of any recent waste disposal at this station and the mean fecal coliform bacteria density was 330/100 ml.

Station 04, on Big Shongelo Creek 1.5 miles upstream from Station 03, had a mean fecal coliform bacteria density of 270/100 ml for the entire study period. The mean fecal coliform density at this station was higher during the July 1971 study than during the May 1972 study (Tables II and III, Figure 3).

Station 05 was located at the concrete spillway at Shongelo Recreation Area Lake. The mean fecal coliform density of 13/100 ml was indicative of little fecal contamination. As shown in Figure 3, the mean fecal coliform bacteria density was slightly higher in the July 1971 study than in the May 1972 study. Swimmers were observed on several different days during the July 1971 study; however, none were seen during the May 1972 sampling period.

13-a

FIGURE 3
FECAL COLIFORM BACTERIA DENSITIES AT IMPOUNDMENT SITE 8
STATIONS DURING JULY, 1971 AND MAY, 1972 STUDIES



Station 06, located on Big Shongelo Creek within the Bienville National Forest, had a mean fecal coliform bacteria density of 220/100 ml. There was little difference between the July 1971 and May 1972 mean densities at this station.

Fecal Streptococcus Bacteria

Fecal streptococcus bacteria analyses were performed to aid in establishing whether pollution in the study areas was primarily of animal or human origin. It has been found that fecal coliform to fecal streptococcus (FC/FS) ratios are useful in indicating the origin of fecal pollution. A fecal coliform to fecal streptococci ratio of greater than 4.0 is regarded as evidence of pollution derived primarily from human origin, whereas an FC/FS ratio of 0.7 or less suggests pollution derived predominantly or entirely from livestock, wildlife, and/or poultry.(7) Ratios just below 4.0 are still suggestive of waste primarily of human origin, and ratios slightly greater than 0.7 are still suggestive of wastes of animal origin. A truly "gray-area" of interpretation is in the ratio range of 1.0 to 2.0. Interpretation of ratios in this area should be used with great caution.

Any ratio must be applied in areas where the time of travel from the wastes sources at the sampling points is less than 24 hours because of the differences in die-off rates of the two bacterial groups.

The mean fecal streptococci bacteria densities for each study period and the entire study period are contained in Tables II, III

and IV. As was the case with fecal coliform densities, the mean fecal streptococci bacteria densities were consistently higher during the July 1971 study than during the May 1972 study (Tables II and III).

Station 03 had the highest mean fecal streptococci density (2800/100 ml) for the July 1971 study period. As previously mentioned, the clandestine dumping of solid waste within the immediate vicinity of this station possibly indirectly influenced the fecal streptococci densities.

The fecal coliform to fecal streptococci ratios for the entire study period are contained in Table V. With one exception, the ratios obtained were 0.35 or less which indicates pollution originating predominantly from livestock, wildlife, poultry, and other non-human fecal material. This agrees with the results of the waste source inventory which indicated an absence of domestic wastes. Station 05 had a ratio within the "gray-area" of interpretation. The "gray" FC/FS ratio at this station resulted from the very low mean fecal coliform and fecal streptococci densities obtained and no clear interpretation would be expected.

Salmonella Isolation

In addition to the determinations of fecal coliforms and fecal streptococci, special efforts were made to detect members of the genus *Salmonella* at selected stations.

Salmonella is a large serologically related genus comprised of some 1,300 serotypes. *Salmonella* is probably the easiest enteric

TABLE V

COMPARISONS OF THE GEOMETRIC MEAN FECAL COLIFORM AND FECAL STREPTOCOCCI BACTERIA DENSITIES FOR THE ENTIRE STUDY PERIOD

Station	Geometric Mean Fecal Coliforms per 100 ml	Geometric Mean Fecal Streptococci per 100 ml	FC/FS*
01	320	1,100	0.29
02	340	1,100	0.31
03	660	1,900	0.35
04	270	1,800	0.15
05	13	5	2.60
06	220	1,600	0.14

*FC/FS - $\frac{\text{Geometric mean fecal coliform bacteria/100 ml}}{\text{Geometric mean fecal streptococci bacteria/100 ml}}$

pathogen to isolate from environmental waters. All Salmonella are considered pathogenic for man, animals, or both. The presence of Salmonella is proof of fecal contamination and establishes the disease-producing potential of the water.

Table VI lists the stations where Salmonella isolation was attempted and the serotypes isolated. Several facts should be noted regarding the Salmonella isolations. Six serotypes were isolated at Station 02 on Little Shongelo Creek during the July 1971 survey. No definitive explanation can be given for the variety of isolates at this station. However, there were unconfirmed reports of a beaver-dam upstream of this station and the possibility of beaver as the source of the Salmonella exists. The recovery of two Salmonella serotypes at Station 05 when the mean fecal coliform bacteria density was 25/100 ml simply underscores the fact that low indicator levels alone do not negate the possibility of enteric pathogen presence.

Flow Determinations

The average estimated streamflows for the July 1971 and May 1972 studies are shown in Table VII. In July 1971, average flows ranged from 0.3 cfs at Station 06 to 1.2 cfs at Station 01. The average flows during the May 1972 survey were from two to four times greater than the July 1971 flows. Figure 4 illustrates a comparison of the average estimated flows at the Shongelo and Big Shongelo Creek stations during the two survey periods.

TABLE VI

SALMONELLA SEROTYPES RECOVERED DURING THE
JULY 1971 AND MAY 1972 STUDIES

Station Number	Salmonella Serotypes	
	July 1971	May 1972
01	S. give, S. luciana	None Recovered
02	S. muenchen, S. give, S. gaminara, S. newport, S. bredeney, S. java	None Recovered
03	S. gaminara	None Recovered
04	S. infantis	S. heidelberg
05	S. newport S. bareilly	S. bredeney
06	S. infantis, S. bareilly	None Recovered

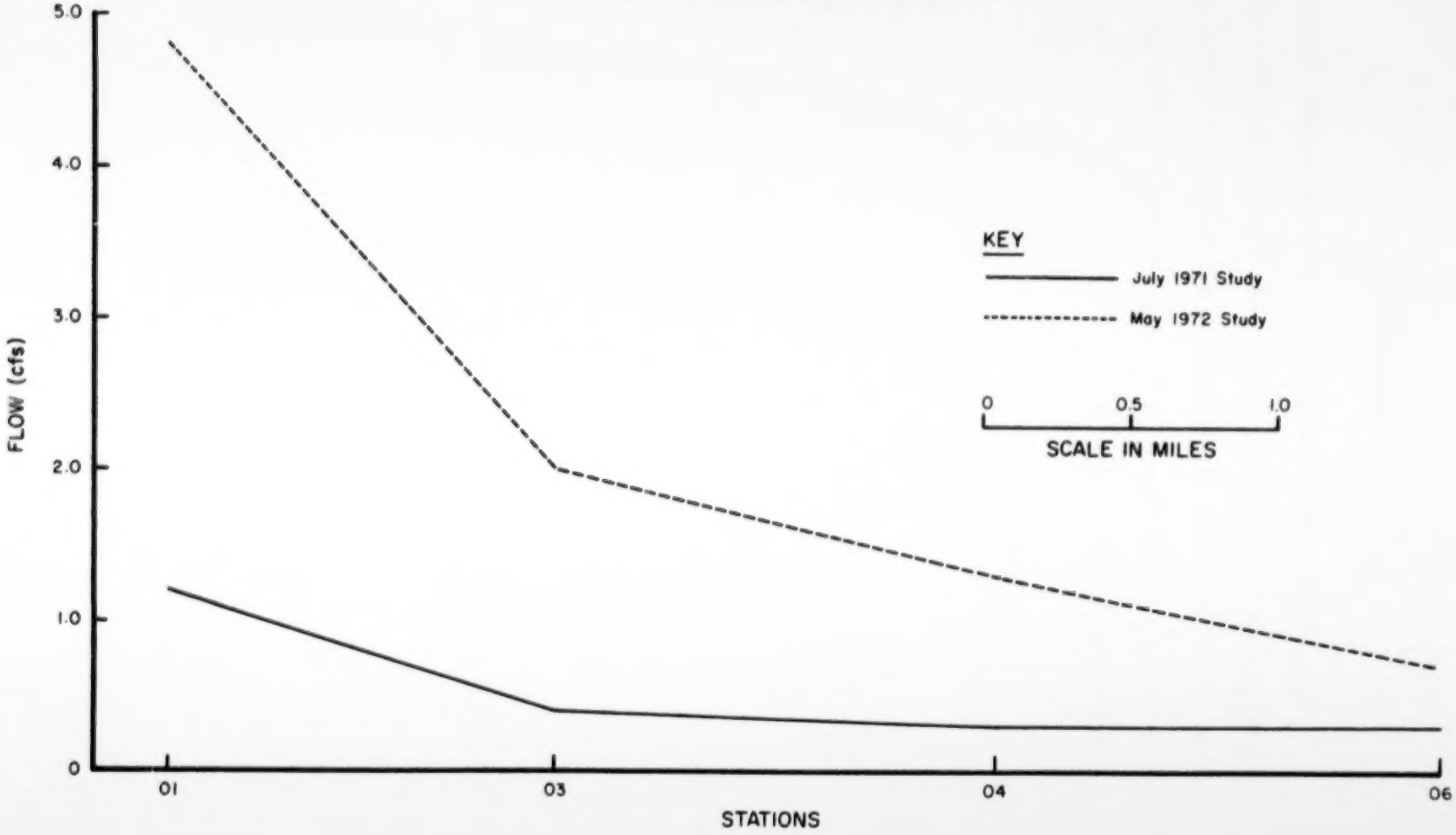
16-a

TABLE VII

AVERAGE ESTIMATED STREAMFLOWS DURING THE
JULY 1971 AND MAY 1972 STUDIES

Station	July 1971 Average Flow (CFS)	May 1972 Average Flow (CFS)
01	1.2	4.8
02	0.8	2.0
03	0.4	2.0
04	0.3	1.3
05	<0.5	0.5
06	0.3	0.7

FIGURE 4
COMPARISON OF THE AVERAGE FLOWS IN SHONGELO
AND BIG SHONGELO CREEK



16-C

Temperature

Water temperatures at the Site 8 stations ranged from 22.0°C to 31.0°C during the July 1971 study. The average temperatures ranged from 23.9°C to 29.4°C (Table VIII). During the May 1972 study, the temperatures ranged from 17.0°C to 23.5°C, and the average station temperatures ranged from 17.2°C to 22.5°C.

TABLE VIII

WATER TEMPERATURE DATA SUMMARY FOR THE
JULY 1971 AND MAY 1972 STUDIES

Station Number	Water Temperature °C					
	July 1971			May 1972		
	Maximum	Minimum	Average	Maximum	Minimum	Average
01	26.5	23.0	24.2	18.0	17.0	17.7
02	29.0	23.5	25.8	19.0	18.0	18.3
03	25.0	22.5	23.9	18.0	17.0	17.3
04	26.0	22.5	24.7	17.5	17.0	17.2
05	31.0	29.0	29.4	23.5	22.0	22.5
06	27.5	22.0	24.0	18.0	17.0	17.3

IMPOUNDMENT SITE 4

Bacterial Results

Coliform Bacteria

During the July 1971 study there was no base streamflow in the entire Site 4 drainage area. On July 19 one sample was collected at Station 07 (Ichusa Creek immediately downstream of the proposed damsite). There was flowing water at this point as a result of rainfall which occurred on the night of July 16, and the morning of July 17 (Appendix B). The fecal coliform bacteria density of the sample was 1100/100 ml (Appendix C).

The bacterial data summary for the May 1972 study is contained in Table IX. During the first two days of the May 1972 study there was only one flowing point (Station 07).

As a result of rainfall in the area, during the second day of sampling, four flowing points were sampled to determine the effect of surface runoff on the bacterial quality of the water. Figure 5 illustrates the impact of the surface runoff on stream flow and fecal coliform density at Station 07. As shown, the fecal coliform bacteria density increased from 350/100 ml before the rain to >50,000/100 ml in approximately 24 hours. Within the next 24 hours the fecal coliform bacteria density had decreased to 3100/100 ml.

The fecal coliform density at Stations 08, 09, and 10 followed basically the same pattern of extremely high densities during the first 24 hours of runoff and decreasing densities in the succeeding 24 hours (Table X). The effects of the surface runoff on the bacterial quality of the water was quite dramatic since lack of base flow precluded any dilution of the runoff. These high bacterial densities would be expected after each rainfall within this drainage area.

TABLE IX

Impoundment Site 4 Bacteriological Data Summary
May 1972 Study

Sta.	Fecal Coliform/100 ml				Fecal Streptococci/100 ml				No. of Samples	FC/FS* Ratio
	Maximum	Minimum	Average	Geo. Mean	Maximum	Minimum	Average	Geo. Mean		
07	>50,000	320	12,000	2,800	11,000	130	3,300	1,400	12	2.00
08	>50,000	990	19,000	7,000	18,000	1,700	7,700	5,100	6	1.37
09	>50,000	300	25,000	7,500	15,000	600	4,600	2,800	7	2.68
10	>50,000	1,200	20,000	8,200	15,000	2,000	7,100	5,900	6	1.39

*FC/FS = $\frac{\text{Geometric Mean Fecal Coliforms/100 ml}}{\text{Geometric Mean Fecal Streptococci/100 ml}}$

TABLE X

Fecal Coliform Bacteria Densities at Impoundment Site 4 Stations During Period of Surface Runoff

Date	Time	Fecal Coliforms/100 ml		
		Station 08	Station 09	Station 10
5-2-72	1200	No Flow	No Flow	No Flow
5-2-72	1510	No Flow	23,000	No Flow
5-3-72	1030 ± 30	11,000	>50,000	>50,000
5-3-72	1445 ± 45	>50,000	>50,000	50,000
5-3-72	1810 ± 10	>50,000	>50,000	13,000
5-4-72	0900 ± 25	2,300	1,100	5,500
5-4-72	1230 ± 15	1,800	1,400	1,200
5-4-72	1630 ± 15	990	300	1,400

Fecal Streptococcus Bacteria

The summary of the fecal streptocci data is presented in Table IX. The mean fecal streptococci densities ranged from 1400/100 ml at Station 07 to 5900/100 ml at station 10. The fecal coliform to fecal streptococci ratios presented in Table IX ranged from 1.37 to 2.68. All ratios were in the "gray area" of interpretation and no conclusions using these ratios could be drawn as to the origin of the fecal waste. This is as expected since most the bacterial densities enumerated at the Site 4 stations resulted from multiple fecal wastes scoured from the drainage area by surface runoff.

Salmonella Isolation

Isolation for the genus Salmonella was attempted at Station 07 only, since this was the only station with base flow during the May 1972 study. Salmonella inverness was isolated at this station. No attempt was made to isolate Salmonella at the Site 4 stations during July 1971.

Flow Determination

There was no base flow at 3 of the Site 4 stations during the July 1971 study. There was some flow, estimated to be <0.1 cfs, at Station 07 following rain in the drainage area.

During the May 1972 study there was base flow at Station 07, only (estimated to be <0.1 cfs). While this study was being conducted approximately 1.0 inch of rainfall occurred within the Site 4 drainage area. As a result of surface runoff, the streamflow at Station 07

peaked at approximately 7.0 cfs (Figure 5). The peak flows at Stations 08 and 10 were estimated at 6.0 cfs and 20 cfs, respectively (Appendix C). No flow determinations could be made at Station 09. Within 72 hours after the beginning of the rainfall, there was no flowing water at Stations 09 and 10.

Temperature

Water temperatures at the Site 4 stations ranged from 14.5°C to 24.5°C. The average temperatures ranged from 17.4°C to 18.8°C (Appendix C).

PROJECTED BACTERIOLOGICAL WATER QUALITY OF THE PROPOSED IMPOUNDMENTS

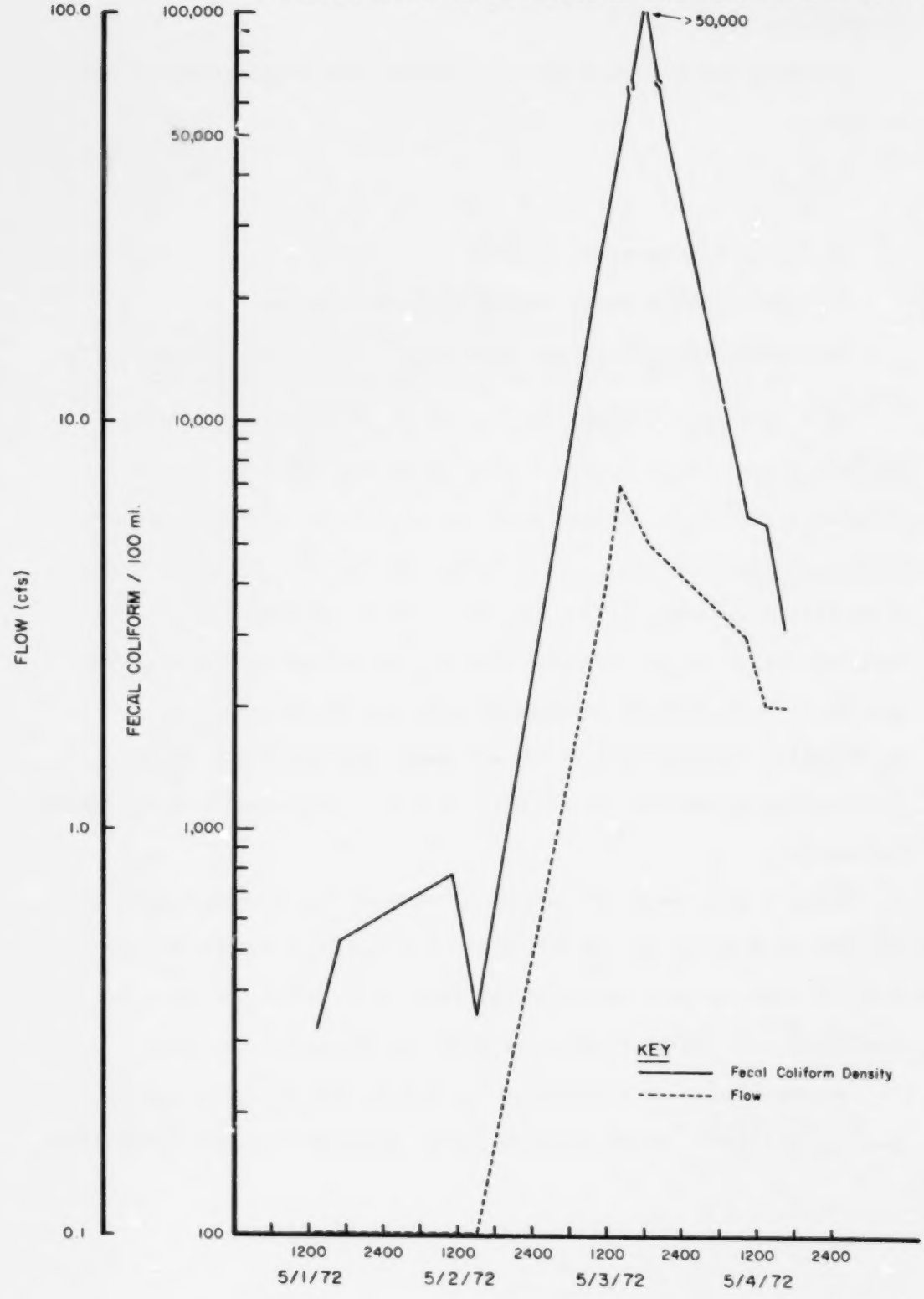
IMPOUNDMENT SITE 8

Existing bacterial water quality within the drainage area together with runoff data and proposed reservoir volume is used as a base for estimating future impoundment bacterial quality.

Runoff data from the Upper Leaf River Watershed for the period 1951-1960 were used to obtain an estimate of runoff within the impoundment drainage area.(8) An average runoff for the months of June, July, and August are used for predictive pruposes. Records show that an average 0.50 inches of runoff per month occurred during the recreation season of the above 10-year period.

Impoundment drainage area and projected reservoir volume data were obtained from the Soil Conservation Service.(1) The drainage

FIGURE 5
COMPARISON OF THE FECAL COLIFORM DENSITY AND FLOW AT STATION 07 DURING THE MAY 1972 STUDY



area for Site 8 is 7690 acres and the projected recreational pool volume is 3062 acre feet.

Applying the following mixing equation, some rough estimates can be made.

$$\frac{C_1Q_1 + C_2Q_2}{Q_1 + Q_2}$$

C_1 = mean FC density of runoff

Q_1 = acre feet of runoff during recreation season

C_2 = mean FC density of the impoundment when filled (estimated to be 25/100 ml when not under heavy runoff influence)

Q_2 = acre feet of impoundment at normal recreation pool level

Applying a mean runoff fecal coliform density of 660/100 ml (highest mean density measured during the entire study), an estimated mean FC density of 31/100 ml would occur throughout the lake. Naturally, such a projection assumes complete and instantaneous mixing of runoff and reservoir water and no bacterial dieoff. Consequently, such a projection would be considered excessively high for the reservoir as a whole. In actuality, counts would be highest near tributaries and lowest near the impoundment outlet. Nevertheless the above technique provides useful information.

Using a mean runoff FC density of 5000/100 ml, a value higher than any density measured at the Site 8 stations during a runoff period, and with all other factors remaining the same, a projected reservoir FC density of only 75/100 ml would be expected throughout the lake.

Another factor to consider in estimating future impoundment bacterial quality is dieoff. Fecal coliform dieoff patterns have been established

from considerable amounts of stream data.(9) Although the dieoff response may vary from stream to stream, some general relationships have been established. Figure 6 shows a general dieoff pattern for fecal coliform during summer months. The dieoff curve represents the percent of the initial density remaining with time.

Applying the general dieoff pattern in Figure 6 to the maximum mean FC density measured at Site 8 indicates that a recreational criterion of 200/100 ml could easily be attained in those areas of the lake one day's flow time from the point of tributary discharge. This assumes no dilution and no additional indicator bacteria being added within the course of travel.

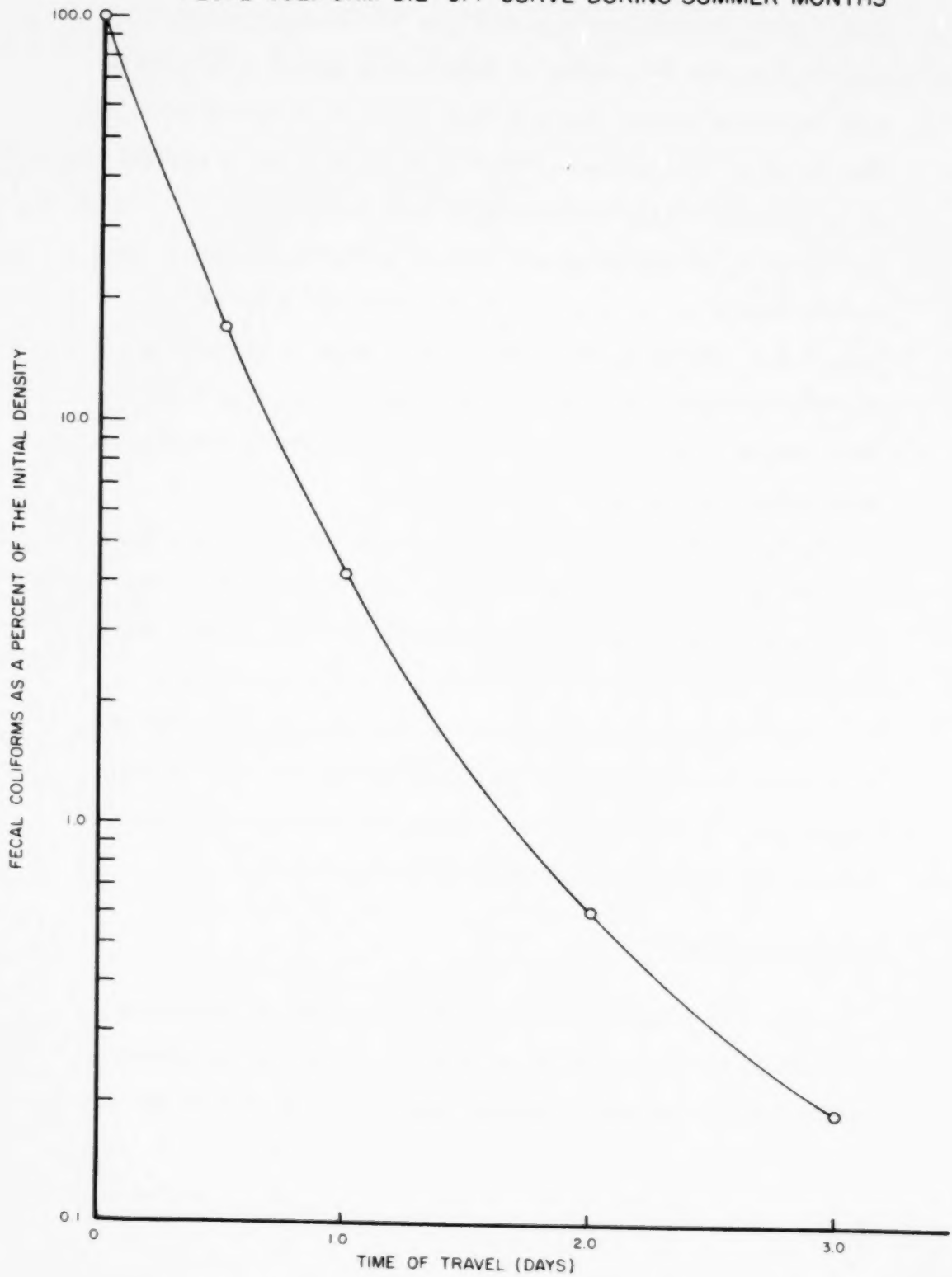
Based on the dieoff pattern presented in Figure 6, much higher FC densities than those observed during this study would be required before violation of the recreational criterion would occur. This is especially true when the time of travel is 1.5 days or greater.

From the dilution projections together with the knowledge that considerable bacterial dieoff will occur within the lake, it would appear that the bacterial quality within the Site 8 impoundment will be more than sufficient to support water contact activities.

IMPOUNDMENT SITE 4

This site presents a rather unique situation in that during portions of the year there is no base flow in any of the streams within the drainage area. Another feature of this site is the

FIGURE 6
FECAL COLIFORM DIE-OFF CURVE DURING SUMMER MONTHS



rapid runoff following rainfall. For these reasons, the Site 4 impoundment will be subjected to periodic influxes of runoff carrying high bacterial indicator levels.

Applying the mixing equation previously used and substituting the mean FC densities measured at Site 4, the drainage area and pool volume, some estimates of future bacteriological quality are again made. The maximum and minimum FC densities measured were 8200 and 2800/100 ml. The drainage area for Site 4 is 9864 acres and the projected recreational pool volume is 6476 acre feet. As with Site 8, a mean runoff of 0.50 inches per month during the recreation season represents the incoming volume being discharged into the impoundment. A background FC density of 25/100 ml is assumed for the lake when completely filled.

Using these figures and applying the maximum and minimum mean FC densities, the projected mean FC densities in the lake would be 490 and 180/100 ml, respectively. Although these projected densities are rough estimates, they do indicate the quality within this impoundment could be marginal for water contact activities. Undoubtedly, there will be higher densities adjacent to tributaries.

The apparent dramatic effect that rainfall in the Site 4 area has on both runoff and the high bacterial densities transported by this runoff makes projection of future bacteriological quality of the impoundment difficult. However, based on the high FC densities measured during the May 1972 study, indications are that the bacterial quality of the proposed impoundment would be marginal for water contact activities with all factors affecting bacterial quality considered.

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STUDY METHODS

BACTERIOLOGICAL SAMPLING

All stream samples analyzed for indicator bacteria were collected near the surface using a grab technique. The samples were collected in sterile glass containers and placed on ice until time of analysis. Most samples were analyzed within four hours of collection.

Stream samples collected for the purpose of isolating Salmonella were obtained using a modification of the swab technique of Moore (10). Sanitary napkins (swabs) were folded, gauze ends tied together, and a length of heavy string attached. The swabs were then wrapped in kraft paper and sterilized. The sterile swabs were suspended beneath the water surface at selected sampling stations. After three to five days, the swabs were retrieved, placed in sterile plastic bags, and returned to the laboratory for analysis.

BACTERIOLOGICAL EXAMINATION

Fecal Coliform Enumeration

The fecal coliform membrane filter procedure outlined in Standard Methods (11) was used. The procedure employs M-FC medium at an incubation temperature of $44.5 \pm 0.2^{o}C$ (waterbath) for 24 hours.

Fecal Streptococci Enumeration

The membrane filter technique outlined in Standard Methods (11) was used. The method employs M-Enterococcus agar incubated at $35 \pm 0.5^{o}C$ for 48 ± 3 hours.

Salmonella Isolation and Identification

Swabs used for isolation purposes were placed into wide-mouthed jars containing approximately 200 ml of 1 1/2 strength tetrathionate broth with brilliant green added. The inoculated enrichment was incubated from 24 to 48 hours at 41.5°C according to the procedure of Spino (12). After either primary or sub-culture enrichment, an inoculum from each enrichment was streaked onto Xylose Lysine Desoxycholate Agar (XLD) and Hektoen Enteric Agar (HE) plates and incubated at 35° ± 0.5°C for 18-24 hours. Suspected *Salmonella* colonies were picked from the respective plates and subjected to the identification scheme outlined in Table XI.

The methods and media outlined in Table XI are described by Ewing (13), with the exception of the cytochrome oxidase method. Oxidase activity was determined using Patho-Tec-CO[1/] reagent impregnated strips.

Definitive serological identification of *Salmonella* isolates was made at the Southeast Water Laboratory. The methodology used was the standard serological procedures described by Edwards and Ewing (14).

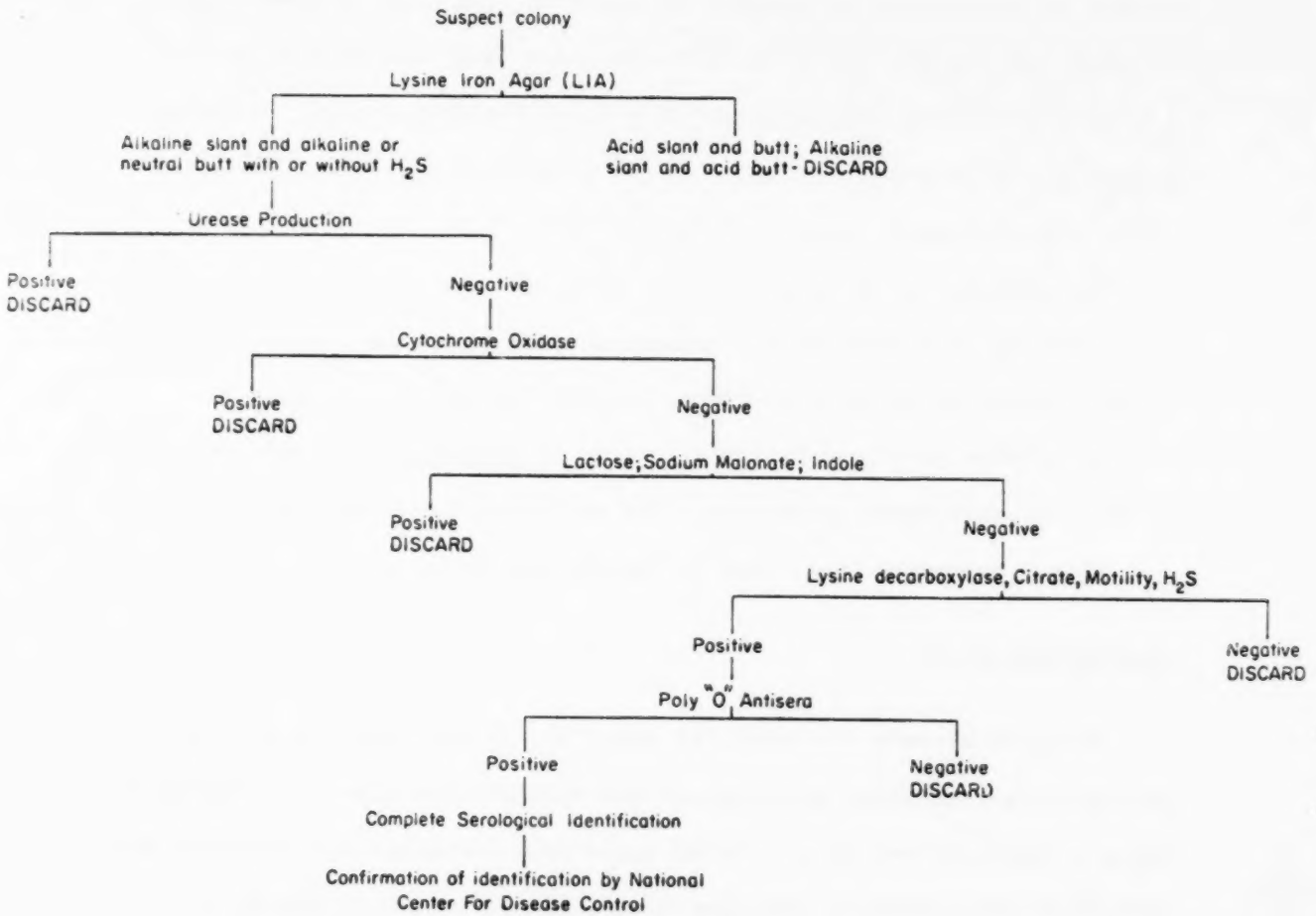
FLOW DETERMINATION

Streamflows were estimated, if possible, at each sampling station. Average cross-sectional measurements and average velocities were determined using a Pygmy current meter. Staff gages were installed for reference and velocities were measured each time the staff gage reading changed.

1/ Does not imply endorsement of the product.

Table XI

IDENTIFICATION SCHEME FOR SALMONELLA SUSPECTS



Rainfall Data

Date	Rainfall (inches)		
	Forest, Miss.[1/]	Mize, Miss.[1/]	White Oak, Miss.[1/]
July 13, 1971	0.05	0	0
July 14, 1971	0	0.22	0
July 15, 1971	0	0	0
July 16, 1971	2.19	0	0
July 17, 1971	0	0	1.43
July 18, 1971	0	0	0
July 19, 1971	0	0	0
May 1, 1972	0	0.50	0
May 2, 1972	0.11	0.80	0.17
May 3, 1972	0	0	0.54
May 4, 1972	0	0	0

[1/] National Oceanic and Atmospheric Administration weather stations nearest to the two study areas.

C-1

STORET RETRIEVAL DATE 72/06/02
274540 01 M-129-02
32 03 33.0 089 28 58.0
LEAF R.-SHONGELO CREEK
28 MISSISSIPPI
SOUTHEAST
PASCAGOULA RIVER BASIN
11135050 2111204
3 0000 FEET DEPTH

DATE FROM TO	TIME OF DAY	DEPTH FEET	00010 WATER TEMP CENT	00061 STREAM FLOW, INST-CFS	31616 FEC COLI MFM-FCHR /100ML	31679 FECSTREP MF M-ENT /100ML
71/07/13	09 55		23.0	1	240	1300
71/07/14	09 50		23.5	1	220	1400
71/07/15	08 07		23.5	1	350	1400
	13 20		26.5	1	190	1000
71/07/16	09 30		24.0	1	230	1500
71/07/19	12 15		24.5	2	2600	2900
72/05/01	11 50		18.0	5	95	200
72/05/02	09 25		18.0	5	1200	1200
72/05/04	15 00		17.0	5	130	700

STORET RETRIEVAL DATE 72/06/02
274542 02 M-129-03
32 03 59.0 089 29 29.0
LEAF R.-LITTLE SHONGELO CREEK
28 MISSISSIPPI
SOUTHEAST
PASCAGOULA RIVER BASIN
11135050 2111204
3 0000 FEET DEPTH

DATE FROM TO	TIME OF DAY	DEPTH FEET	00010 WATER TEMP CENT	00061 STREAM FLOW, INST-CFS	31616 FEC COLI MFM-FCBR /100ML	31679 FECSTREP MF M-ENT /100ML
71/07/13	09 35		23.5	1	320	810
71/07/14	09 35		24.0	1	300	1600
71/07/15	09 10		24.0	1	420	1400
	13 35		28.0	1	310	760
71/07/16	09 40		29.0	1	210	1900
71/07/19	13 15		26.0	1	510	1200
72/05/01	12 15		18.0	2	380	700
72/05/02	09 45		18.0	2	460	1200
72/05/04	14 45		19.0	2	260	800

C-3

STORET RETRIEVAL DATE 72/06/02
274544 03 M-129-04
32 04 22.0 089 29 29.0
LEAF R.-BIG SHONGELO CREEK
28 MISSISSIPPI
SOUTHEAST
PASCAGOULA RIVER BASIN
11135050 2111204
3 0000 FEET DEPTH

DATE FROM TO	TIME OF DAY	DEPTH FEET	00010 WATER TEMP CENT	00061 STREAM FLOW, INST-CFS	31616 FEC COLI MFM-FCHR /100ML	31679 FECSTREP MF M-ENT /100ML
71/07/13	09 30		22.5	0.3	760	4200
71/07/14	09 30		23.5	0.3	550	2700
71/07/15	08 45		24.0	0.3	930	2400
	13 45		25.0	0.3	510	2400
71/07/16	09 45		24.5	0.3	930	2600
71/07/19	14 15		24.0	1	3800	2900
72/05/01	12 22		17.0	2	320	600
72/05/02	10 00		18.0	2	610	1500
72/05/04	14 35		17.0	2	180	700

STORET RETRIEVAL DATE 72/06/02
274546 04 M-129-05
32 05 22.0 089 29 43.0
LEAF R.-BIG SHONGELO CREEK
28 MISSISSIPPI
SOUTHEAST
PASCAGOULA RIVER BASIN
1113S050 2111204
3 0000 FEET DEPTH

DATE FROM TO	TIME OF DAY	DEPTH FEET	00010 WATER TEMP CENT	00061 STREAM FLOW, INST-CFS	31616 FEC COLI MFM-FCBR /100ML	31679 FECSTREP MF M-ENT /100ML
71/07/13	08 50		22.5	0.3	480	2400
71/07/14	10 05		24.0	0.3	270	2300
71/07/15	09 50		24.5	0.3	280	1900
	13 55		26.0	0.3	240	1900
71/07/16	10 00		25.0	0.3	240	2900
71/07/19	14 40		26.0		410	2000
72/05/01	10 35		17.0	1	280	820
72/05/02	10 10		17.5	1	210	1900
72/05/04	14 20		17.0	1	130	1100

C-5

STORET RETRIEVAL DATE 72/06/02
274548 05 M-129-06
32 05 40.0 089 30 40.0
LEAF R.-SHONGELO PARK LAKE
28 MISSISSIPPI
SOUTHEAST
PASCAGOULA RIVER BASIN
11135050 2111204
3 0000 FEET DEPTH

DATE FROM TO	TIME OF DAY	DEPTH FEET	00010 WATER TEMP CENT	00061 STREAM FLOW, INST-CFS	31616 FEC COLI MFM-FCBK /100ML	31679 FECSTREP MF M-ENT /100ML
71/07/13	10	20	29.0	0.5K	17	4
71/07/14	10	30	29.0	0.5K	50	1
71/07/15	10	15	29.0	0.5K	26	18
	14	10	31.0	0.5K	18	2K
71/07/16	09	10	29.0	0.5K	28	6
71/07/19	14	50			20	8
72/05/01	10	55	22.0	0.5	2	10
72/05/02	09	05	22.0	0.5	2	7
72/05/04	15	25	23.5	0.5	10	5

STORET RETRIEVAL DATE 72/06/02
274550 06 M-129-07
32 06 54.0 089 30 05.0
LEAF R.-BIG SHONGELO CREEK
28 MISSISSIPPI
SOUTHEAST
PASCAGOULA RIVER BASIN
1113S050 2111204
3 0000 FEET DEPTH

DATE FROM TO	TIME OF DAY	DEPTH FEET	00010 WATER TEMP CENT	00061 STREAM FLOW, INST-CFS	31616 FEC COLI MFM-FCBR /100ML	31679 FECSTREP MF M-ENT /100ML
71/07/13	10 35		23.0	0.3	220	2300
71/07/14	10 40		22.5	0.3	170	2600
71/07/15	10 25		24.0	0.3	270	3600
	14 20		27.5	0.3	110	1600
71/07/16	08 55		22.0	0.3	380	3800
71/07/19	15 05		25.0	0.3	360	1400
72/05/01	10 15		17.0	1	160	760
72/05/02	08 50		18.0	1	400	
72/05/04	14 00		17.0	1	110	350

C-7

STORET RETRIEVAL DATE 72/06/02
274552 07 M-129-08
32 09 10.0 089 23 01.0
LEAF R.-ICHUSA CREEK
28 MISSISSIPPI
SOUTHEAST
PASCAGOULA RIVER BASIN
11135050 2111204
3 0000 FEET DEPTH

DATE FROM TO	TIME OF DAY	DEPTH FEET	00010 WATER TEMP CENT	00061 STREAM FLOW, INST-CFS	31616 FEC COLI MFM-FCBR /100ML	31679 FECSTREP MF M-ENT /100ML
71/07/19	11 50		24.5	0.1K	1100	4800
72/05/01	13 00		18.0	0.1K	320	150
	17 00		22.0	0.1K	520	140
72/05/02	08 20		18.0	0.1K	730	200
	11 00		18.0	0.1K	770	130
	14 30		19.0	0.1K	350	950
72/05/03	10 00		17.5	3	24000	11000
	13 30		18.5	7	50000	4100
	17 45		19.0	5	50000L	3300
72/05/04	09 50		15.5	3	5800	5500
	13 15		17.0	2	5600	4800
	16 05		18.0	2	3100	4800

STORET RETRIEVAL DATE 72/06/02
274554 08 M-129-09
32 09 51.0 089 22 40.0
LEAF R.-ICHUSA CREEK
28 MISSISSIPPI
SOUTHEAST
PASCAGOULA RIVER BASIN
1113S050 2111204
3 0000 FEET DEPTH

DATE FROM TO	TIME OF DAY	DEPTH FEET	00010 WATER TEMP CENT	00061 STREAM FLOW, INST-CFS	31615 FEC COLI MFM-FCBR /100ML	31679 FECSTREP MF M-ENT /100ML
72/05/03	10 10		17.5	3	11000	6100
	14 00		19.5	6	50000L	18000
	18 00		18.0	5	50000L	15000
72/05/04	09 10		15.0	3	2300	3300
	12 35		16.5	2	1800	1800
	16 15		18.0	1	990	1700

STORET RETRIEVAL DATE 72/06/02
274556 09 M-129-10
32 10 08.0 089 23 39.0
LEAF R.-TRIB. TO ICHUSA CREEK
28 MISSISSIPPI
SOUTHEAST
PASCAGOULA RIVER BASIN
1113S050 2111204
3 0000 FEET DEPTH

DATE FROM TO	TIME OF DAY	DEPTH FEET	00010 WATER TEMP CENT	00061 STREAM FLOW, INST-CFS	31616 FEC COLI MFM-FCBR /100ML	31679 FECSTREP MF M-ENT /100ML
72/05/02	15	10	19.0		<3000	15000
72/05/03	10	20	18.0		>80000L	6500
	14	10	19.0		>80000L	3400
	18	05	18.5		>80000L	4300
72/05/04	09	00	14.5		1100	1100
	12	45	16.0		1400	1600
	16	20	17.0		300	600

STORET RETRIEVAL DATE 72/06/02
274558 10 M-129-11
32 11 51.0 089 22 36.0

28

11135050 2111204
3 0000 FEET DEPTH

DATE FROM TO	TIME OF DAY	DEPTH FEET	00010 WATER TEMP CENT	00061 STREAM FLOW, INST-CFS	31616 FEC COLI MFM-FCBR /100ML	31679 FECSTREP MF M-ENT /100ML
72/05/03	10 55		17.5		50000L	15000
	15 30		18.0	2	50000	9000
	18 20		17.5		13000	6500
72/05/04	08 35		16.0		5500	6000
	12 25		17.5		1200	3800
	16 40		18.0		1400	2000

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